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TRUCK LOAD SAMPLE SCALING TO ADJUST COMPANY SCALE

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DESCRIPTION OF THE METHOD

A method of sample scaling that adjusts a company's scale to Forest Service standards is proving to be accurate and inexpensive. Since a logging company (or any other purchaser) must scale every load for its own accounting purposes, there is obvious duplication of effort if the Forest Service also scales every load. But since there are certain differences in scaling standards between the Forest Service and most companies and since the Forest Service is required by law to obtain its own measure of all products sold, an independent scale must be made. This paper presents a method for easy preparation of such an independent scale.

Fortunately, an accurate adjustment of the company's scale can be determined from a relatively small sample. The variation between company and Forest Service scales usually is less than the variation in total volume from load to load. For this reason, a smaller sample of truck loads is needed to adjust a company's scale than would be needed to obtain an accurate average volume in conventional sample load scaling. In adjusting a company's scale, every load is scaled by the company, and the total volume is adjusted by a ratio factor obtained by the Forest Service sample scale, as follows:

$$\text{Adjusted total volume} = \left(\text{Company's total volume}\right)\left(\frac{\text{Forest Service scaled volume of sample loads}}{\text{Company's scaled volume of the same loads}}\right)$$

Certain obvious precautions must be taken in this sampling process: The sample loads must be selected strictly at random and without the previous knowledge of the company scaler. This assures that the same standard of scaling is applied to all loads. If different sized trucks are operating on the sale, the sample should be chosen in a representative fashion, that is, by stratified random sampling. Care must be taken that all loads are accounted for in determining the company's total volume. If loads contain two or more species, volumes of which must be determined separately, the volume by species

per load becomes the sampling unit rather than the total load volume. The same principles of determining sample size apply regardless of the unit used.[1/]

REQUIRED SAMPLE SIZE

In any sampling process, three factors determine sample size: (1) the desired accuracy at a prescribed level of probability, (2) the total number of sampling units in the population, and (3) the variation among sampling units. The first of these is established by policy, and the second is estimated from the cruise. The variation must be determined from a representative sample of 20 to 30 units, from which an adjustment factor and its standard error are computed.

The adjustment factor, in this case, can be considered a regression coefficient, "b," which is the ratio of $\sum^{n}(y)$, the sum of the Forest Service scaled volumes, to $\sum^{n}(x)$, the sum of the company scaled volumes of the same loads, or

$$b = \frac{\sum^{n}(y)}{\sum^{n}(x)}$$

The accuracy of "b" is pertinent to the problem, and this is determined, of course, by the standard error of "b" for a particular situation. The method of calculating the standard error of "b" is expanded in the appendix to this report where the factor "C" is used as a measure analagous to the common coefficient of variation. The required sample size, "n," for different accuracies, sale sizes, and variations can be computed in the conventional manner. (See appendix for equations and numerical example.)

After computing the required sample size, "n," a sampling scheme can be worked out to collect this sample in an unbiased, random fashion during the course of the sale. The final adjustment factor is then based on all the sample loads.

Table 1 shows the required sample size for various values of "C," for accuracies, "E," of 0.01 to 0.04, and for total number of units of 200 to 2,000, computed at approximately the 95-percent probability level. Intermediate values not shown in the table can be determined by plotting sample size over the variable in question (using values from the table) while holding the other two variables constant. After fitting a free-hand curve through the plotted points, interpolated values can be read from the curve. Other values can be computed, of course, by means of the equations shown in the appendix.

1/ This assumes that the same accuracy standard by volume applies to all species. A more refined method of sampling where limits of accuracy are set on value rather than volume is beyond the scope of this paper.

Table 1.--Number of units, "n," needed in a sample for various accuracies, various values of "C," and various sale sizes. Computed at the 95-percent probability level

Total number units	C = 0.05				C = 0.10				C = 0.15				C = 0.20			
	Accuracy percent				Accuracy percent				Accuracy percent				Accuracy percent			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	-n-															
200	67	22	11	6	133	67	36	22	164	106	67	44	178	133	94	67
400	80	24	11	6	200	80	40	24	277	144	80	49	245	200	123	80
600	86	24	11	6	240	86	41	24	360	164	86	51	320	240	137	86
800	89	24	11	6	267	89	42	24	404	172	89	52	533	267	145	89
1,000	91	24	11	6	286	91	43	24	474	184	91	53	615	286	151	91
2,000	95	25	11	6	333	95	43	25	621	202	95	55	889	333	163	95

APPENDIX

Numerically, the accuracy of a regression coefficient is its standard error multiplied by the appropriate "t" for a particular probability. That is

$$\text{Accuracy of b} = \frac{s_{y.x}}{\sqrt{\sum^{n}(x)}} \; (t) \sqrt{1 - \frac{n}{N}}$$

where $s_{y.x}$ = standard error of estimate,[2/] or the square root of the mean square of weighted residuals from regression. In formula, its square is

$$s_{y.x}^{2} = \frac{\sum^{n}\left(\frac{1}{x}\, y^{2}\right) - b^{2}\sum^{n}(x)}{n-1}$$

and $\sqrt{1 - \frac{n}{N}}$ = the correction factor for finite populations in which "n" is the number of units in the sample and "N" the number in the population.

The accuracy of "b" expressed as a ratio to "b" is

$$E = \frac{\text{Accuracy of b}}{b}$$

$$\text{or } Eb = \text{Accuracy of b}.$$

2/ Schumacher, F. X., and Roy A. Chapman. Sampling methods in forestry and range management. Duke Univ. School of Forestry Bul. 7, rev., 222 pp., illus. 1954.

Substituting "Eb" for the accuracy of "b" in the first equation and squaring both sides gives

$$E^2b^2 = \frac{s_{y.x}^{\ 2}}{\sum^{n}(x)} \left(t^2\right) \left(1 - \frac{n}{N}\right).$$

Note that $\sum^{n}(x)$ is equivalent to $n\bar{x}$, so

$$E^2 = \frac{s_{y.x}^{\ 2}}{b^2 n\bar{x}} \left(t^2\right) \left(1 - \frac{n}{N}\right).$$

To simplify, let $\dfrac{s_{y.x}^{\ 2}}{b^2\bar{x}} = C^2$, then

$$E^2 = \frac{C^2}{n} \left(t^2\right) \left(1 - \frac{n}{N}\right)$$

$$\text{or } n = \frac{t^2C^2}{E^2 + \dfrac{t^2C^2}{N}}.$$

This is the formula upon which table 1 is based.

Numerical example (only five units are used here for the sake of brevity; twenty to thirty units should be used to get an accurate estimate of the variance of "b"):

x (Company)	y (Forest Service)	$\left(\frac{1}{x} y^2\right)$
(Board feet, Scribner Dec. C)		
457	480	504.16
321	310	299.38
47	67	95.51
50	52	54.08
542	490	442.99
1,417	1,399	1,396.12

$$\bar{x} = 283.4$$

$$b = \frac{1399}{1417} = 0.9873$$

$$s_{y.x}^2 = \frac{1396.12 - (0.9873)^2(1417)}{4}$$

$$= \frac{1396.12 - 1381.29}{4}$$

$$= 3.71.$$

$$C^2 = \frac{3.71}{(0.9872)^2(283.4)} = 0.0134\,.$$

Given $E = 0.02$

$N = 500$

$t = 2$ (for a probability of approximately 95 percent).

Then, $$n = \frac{(2)^2(0.0134)}{(0.02)^2 + \frac{(2)^2(0.0134)}{500}}$$

$$= \frac{0.0536}{0.000507}$$

$$= 106.$$